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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 742

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. January 15, 1919

PRODUCTION OF AMERICAN EGYPTIAN COTTON.

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COMMUNITY PRODUCTION OF COTTON.

The purposes of this bulletin are to tell how Egyptian-cotton production became established in the Southwest as a result of community action, to describe the present status of the industry, and to give the reasons for encouraging the growing of this type of cotton in the United States. Attention is also directed to the conditions which appear to be indispensable to successful commercial production in this country. It is believed that Egyptian cotton can not be profitably grown except under irrigation and in the absence of the boll weevil. This would exclude it from consideration in any portion of what is generally known as the cotton belt.

The principle of community action in cotton production implies the growing of only one variety, the variety selected being that which

[1] This bulletin is largely a revision of Department Bulletin No. 332, entitled "Community Production of Egyptian Cotton in the United States," by C. S. Scofield, T. H. Kearney, C. J. Brand, O. F. Cook, and W. T. Swingle, issued on January 13, 1916.

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is best adapted to the physical and economic conditions of the locality.[1] In no other way is it possible to maintain a supply of pure seed and to market year after year a uniform high-grade product. These objects can be attained only by effective cooperation on the part of the growers. The lesson taught by this successful application of the community principle should make the present publication interesting to many who are engaged in growing, selling, or manufacturing cotton, even though they may not be concerned with the special subject of Egyptian-cotton production.

SOURCES OF LONG-STAPLE COTTON.

The three most important types of long-staple cotton are (1) Sea Island cotton, (2) long-staple Upland cotton, and (3) Egyptian cotton.

Sea Island cotton is grown on the islands along the coasts of South Carolina and Georgia and in certain counties on the mainland of Georgia and Florida, as well as to a limited extent in portions of the West Indies. During recent years the crop of Sea Island cotton in the United States has ranged from 60,000 to 120,000 bales[2] per annum. The staple of Sea Island cotton ranges from 1½ to 1⅝ inches in the Georgia and Florida product to 2 inches in the best qualities grown on the Sea Islands proper.[3]

Long-staple Upland cotton has long been produced chiefly in the so-called Delta region of western Mississippi. In recent years the production of this type of cotton has been extended into eastern Arkansas and northeastern Texas, and a small quantity has also been grown in the Carolinas. Still more recently the growing of long-staple Upland cotton has been established on irrigated lands in the Imperial Valley of California, the industry in that locality being based on the Durango variety. The quantity of long-staple Upland cotton produced annually in the United States is not definitely known. A recent publication of the Bureau of Crop Estimates[4] places the total for 1916 at slightly more than 1,000,000 bales of cotton having a staple of 1⅛ inches or longer. While a few varieties of long-staple Upland cotton sometimes produce fiber having a staple of 1½ inches or longer, the bulk of the crop is less than 1⅜ inches in length.

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[1] Cook, O. F. Cotton improvement on a community basis, *In* U. S. Dept. Agr. Yearbook, 1911, p. 397–410, 1912. See also Swingle, W. T., The fundamentals of crop improvement, in U. S. Dept. Agr., Bur. Plant Indus. Cir. 116, pp. 3–10, 1913.

[2] The Sea Island cotton bale averages in weight slightly less than 400 pounds. For further information, see Meadows, W. R., Economic conditions in the Sea Island cotton industry, U. S. Dept. Agr. Bul. 146, 18 p., 1914.

[3] A small proportion of the island product reaches a length of 2¼ and rarely even 2½ inches.

[4] Monthly Crop Report for June, 1917, p. 52. See also Taylor, Fred, and Sherman, W. A., Spinning tests of Upland long-staple cottons, U. S. Dept. Agr. Bul. 121, 1914, p. 19.

Egyptian cotton until very recently has been produced commercially only in the delta and lower valley of the Nile River, in Egypt. During the 10-year period from 1907 to 1916 the Egyptian crop averaged annually the equivalent of 1,292,400 bales of 500 pounds (see Table I).

CHARACTER AND SUPPLY OF EGYPTIAN COTTON.

Egyptian cotton is a distinct type, both botanically and commercially, comprising several varieties and having staples ranging from $1\frac{1}{4}$ to $1\frac{5}{8}$ inches. The history of cotton growing in Egypt since the present definite type was developed in that country about 65 years ago has been marked by the successive appearance of numerous varieties. Each of these, after having been extensively grown for a number of years, has shown marked deterioration due to intercrossing.

The most striking characteristics of the Egyptian fiber are its length of staple combined with great strength and fineness. The older varieties, Ashmuni and Mit Afifi, are characterized by a brown or, more properly, pinkish buff color of the fiber, but the Sakellaridis variety, which is now highest in favor among spinners, is nearly white, or almost as light in color as Sea Island cotton. In 1916 this variety occupied 62 per cent of the total cotton acreage of Egypt.

Egyptian cotton is used especially in the manufacture of goods in which strength or fineness or a combination of both qualities is desired. Some of the principal articles manufactured from this cotton are sewing thread, hosiery, automobile-tire fabrics, and fine and fancy dress goods. Until a few years ago mercerized fabrics were made only from Egyptian cotton, but the process of mercerization has now been developed so that other cottons can be successfully treated. "Balbriggan" underwear was formerly manufactured exclusively from the brown Egyptian cottons, but dyed white cottons are now also employed for this purpose.

The cotton crop of Egypt is grown entirely on irrigated land in a climate which is practically rainless throughout the period of development of the cotton plants. The absence of rain during the picking season favors the production of clean cotton. During the 10-year period from 1907 to 1916, the area in cotton in Egypt averaged 1,684,000 acres, and the average yield per acre was about 380 pounds.[1]

The recent annual production of cotton in Egypt is shown in Table I.

About 60 per cent of the Egyptian crop is exported to Great Britain. Imports into the United States during the period from 1908 to

[1] These averages are computed from data given in Monthly Return, Ministry of Agriculture (Egypt), Nov. 30, 1917, p. 5.

1913 averaged about 10 per cent of the total, but the proportion has recently increased, this country having received 19, 35, and 17 per cent, respectively, of the cotton produced in Egypt in the calendar years 1914, 1915, and 1916.

TABLE I.—*Total annual production of cotton in Egypt during the 10-year period from 1907 to 1916, inclusive.*[1]

Year.	500-pound bales.	Year.	500-pound bales.
1907	1,431,000	1912	1,484,000
1908	1,335,000	1913	1,517,000
1909	990,000	1914	1,277,000
1910	1,484,000	1915	945,000
1911	1,461,000	1916	1,000,000

[1] Computed from data given in Monthly Return, Ministry of Agriculture (Egypt), Nov. 30, 1917, and Dec. 31, 1917.

AMERICAN CONSUMPTION OF EGYPTIAN COTTON.

Notwithstanding the fact that nearly two-thirds of the American cotton crop is exported[1] for manufacture in foreign countries, a large quantity of raw cotton is imported for manufacture in the United States. By far the larger part of this imported cotton is obtained from Egypt. Table II shows the imports of Egyptian cotton for the past 10 years.

TABLE II.—*Annual imports of Egyptian cotton into the United States for the crop-distribution years*[1] *during the 10-year period from 1907–8 to 1916–17, inclusive.*

Year.	500-pound bales.	Year.	500-pound bales.
1907–8	120,187	1912–13	191,075
1908–9	129,985	1913–14	137,355
1909–10	102,217	1914–15	261,220
1910–11	183,786	1915–16	339,854
1911–12	175,835	1916–17	198,805

[1] The crop distribution year covers the period from September 1 to August 31, inclusive. The figures shown in Table II are compiled from data given in publications of the Bureau of the Census, the imports for the years 1908 to 1912 from Bulletin 117 (1913), p. 9; those for the years 1913 and 1914 from Bulletin 128 (1914), p. 10; and those for 1915 to 1917 from Bulletin 135 (1918), pp. 65–66. In order to complete the 12 months' total for 1917, the imports during the month of August, 1917, were taken from the monthly postal-card report issued by the Bureau of the Census.
The imports markedly declined during the crop-distribution year 1917–18, having amounted to the equivalent of 119,126 bales of 500 pounds each, which is about 60 per cent of the quantity imported during the preceding year.

The shorter kinds of Egyptian cotton ($1\frac{1}{4}$ to $1\frac{3}{8}$ inch staple), the so-called brown Egyptian and Upper Egypt cottons, produced by the Mit Afifi and Ashmuni varieties, respectively, are used by American manufacturers largely as a substitute for American long-staple Uplands of corresponding lengths, the substitution being profitable

[1] This applies to the years preceding the outbreak of the war in Europe. Of the crops produced in 1914, 1915, and 1916, only about one-half was exported.

when the price of American long-staple cottons is relatively high. There is also a certain amount of substitution of the longest Egyptian, especially of the Sakellaridis variety, for the shorter lengths of Sea Island cotton, depending upon the relative prices of the two types. There remains, however, a certain proportion of the imported Egyptian cotton for which no other fiber appears to be a satisfactory substitute.

In view of this fact, the question has been frequently asked whether Egyptian cotton could not be produced in the United States in sufficient quantity to supply at least a part of the home demand. Conditions which have arisen in Egypt since the first attempts were made to answer this question have emphasized the importance of undertaking the production of Egyptian cotton in this country. It has been found that the maintenance of a uniform quality of any of the Egyptian varieties is rendered precarious by the fact that in Egypt distinct varieties are often grown in adjacent fields. There is also a general contamination of the whole Egyptian crop with an inferior and distinct type of cotton known as Hindi.

These conditions make it almost impossible to maintain in Egypt a supply of pure seed of a variety which has reached the stage of commercial production, because all these types of cotton cross freely with each other and adequate precautions are seldom taken to keep the seed of the different kinds separate at the gin. Furthermore, the cotton crop of Egypt suffers severely from insect enemies, notably in recent years from the ravages of the pink bollworm. This pest threatens a serious reduction of the crop, or at least a wide fluctuation in total production from year to year. Thus, it appears unsafe for the numerous American users of this type of cotton to depend solely upon Egypt for their supply of raw material, and the desirability of developing an independent source of supply in the United States has recently been emphasized by the uncertainty attending transportation under war conditions as well as by the need of extra-staple cotton for aeroplane and balloon fabrics and for other military purposes.

PRODUCTION OF EGYPTIAN COTTON IN AMERICA.

Although experiments with the production of Egyptian cotton in the southwestern United States were begun in 1902, it was not until 1912 that it was deemed advisable to recommend the commercial production of the crop. In the spring of that year seed was distributed by the Department of Agriculture to a number of farmers in the Salt River Valley in Arizona and the Imperial Valley in California. As a result of this distribution about 480 acres of cotton were brought through to harvest, and the crop of 1912 amounted to 375 bales of 500 pounds each.

In 1913 the production of Egyptian cotton was confined to the Salt River Valley, where a total of 3,800 acres was planted. Not all of this acreage came to harvest, but the crop for the year amounted to 2,135 bales of 500 pounds each.

In 1914 the area planted in the Salt River Valley amounted to approximately 12,000 acres. On much of this area the conditions were not favorable for large yields because of deficient soil fertility, inadequate preparation of the land, or faulty management of the irrigation. The total crop for the year amounted to 6,187 bales of 500 pounds each. While the average yield per acre shown by these figures is not high, a number of farmers having good land and using good methods obtained more than one bale per acre.

In 1915, owing to the low prices which followed the outbreak of the war in 1914, the area in the Salt River Valley was reduced to 2,330 acres, of which about 2,000 acres were brought through to harvest. In 1916, under the influence of rising prices, 7,433 acres were planted, and about 6,800 acres were harvested.

Prior to 1917 the commercial production of Egyptian cotton in the United States had been practically confined to the Salt River Valley in Arizona. In that year, however, in addition to the 29,000 acres which were harvested in the Salt River Valley, some 4,000 acres were grown on the Yuma Reclamation Project (Arizona and California), and approximately 200 acres were grown in the Imperial Valley in California.

In 1918 the total acreage planted to Egyptian cotton in the United States is estimated at 86,500, including about 78,000 acres in the Salt River and Gila Valleys in Arizona, about 3,000 acres on the Yuma Reclamation Project, about 3,000 acres in the Imperial Valley, approximately 2,000 acres in the San Joaquin Valley, Cal., and more than 500 acres in the Palo Verde Valley, Cal. The experience of previous years has shown, however, that a certain percentage of the acreage planted is sure to be abandoned before picking time, in most cases because of failure to get a good stand. Probably a conservative estimate of the acreage of Egyptian cotton in Arizona and California which was harvested in 1918 is 70,000 acres.

The status of the industry during the first six years of its existence is summarized in Table III.

Several ginning establishments, devoted exclusively to ginning Egyptian cotton, have been erected in the Salt River Valley and on the Yuma Reclamation Project. Each of these is equipped with from 10 to 15 roller gins of the type used for ginning Sea Island cotton. A number of cottonseed-oil mills are operated in the Salt River, Yuma, and Imperial Valleys.

In staple and quality of fiber the American-grown Egyptian cotton is comparable with the best varieties produced in Egypt, although

some spinners prefer the Sakellaridis variety for certain purposes. The crops so far produced have also been of very good grade, comparing favorably with that of the best imported cotton. A large portion of the Egyptian cotton imported into the United States is of low grade or of relatively short staple, i. e., $1\frac{1}{4}$ to $1\frac{3}{8}$ inches. The American-grown Egyptian cotton does not come into competition with the latter class, but only with the better and higher priced varieties.

TABLE III.—*Number of bales, estimated value of the lint, and estimated value of the seed of Egyptian cotton produced in the United States in the years 1912 to 1917, inclusive.*

Year.	Cotton lint in 500-pound bales.	Estimated value—		
		Of lint.	Of seed.	Of total crop.
1912	375	$39,000	$5,000	$44,000
1913	2,135	197,000	28,000	225,000
1914	6,187	483,000	50,000	533,000
1915	1,095	119,000	10,660	129,660
1916	3,331	699,500	86,400	785,900
1917	15,966	5,482,000	619,770	6,101,770

FUTURE POSSIBILITIES OF THE INDUSTRY.

As to the ultimate possible extension of the industry, the Salt River Valley and the neighboring portion of the Gila Valley could probably grow annually from 75,000 to 100,000 acres of Egyptian cotton, taking into account the entire area capable of irrigation both by gravity and by artesian water. This estimate is based upon the belief that in order to maintain a well-balanced agriculture in an irrigated district not more than one-quarter of the total acreage should be annually in cotton. On the same basis the Yuma Valley could grow about 20,000, the Palo Verde Valley about 15,000, and the Imperial Valley about 100,000 acres of Egyptian cotton annually. In the more northern valleys of California the industry is still in the experimental stage, and it is difficult to estimate the possible ultimate production in that locality. An annual area of at least 100,000 acres in the San Joaquin Valley would seem possible.

Heretofore the entire acreage planted to Egyptian cotton has yielded annually an average of about 250 pounds of fiber per acre. But in view of the results which have been obtained every year by farmers skilled in the management of this crop on land which has been enriched by crops of alfalfa, the average yield should ultimately approach one bale (500 pounds) per acre. With a total acreage of 300,000 an annual production in the United States of from 150,000 to 250,000 bales of cotton of the Egyptian type appears to be well within the limit of probability, provided that the prices of the fiber

and seed remain somewhere near the present levels and that labor can be obtained for picking so large an acreage.

COMPARISON OF AMERICAN AND EGYPTIAN CONDITIONS.

The commercial production of Egyptian cotton in the United States involves the marketing of the product in direct competition with the crop of Egypt. This fact warrants a brief consideration of the status of the cotton industry in that country and a comparison between the conditions there and in the southwestern United States. The production in Egypt of cotton having a staple comparable with that of the Salt River Valley product is limited to what is known as Lower Egypt—that is to say, the Nile Delta, north of Cairo. This region includes about 3,250,000 acres of irrigated land, of which about 40 per cent is annually devoted to cotton.

This land is heavily capitalized, and the cost of irrigation water is high. These features are best expressed by rental values, which range for the best land from $50 to $75 a year per acre. It is probable that the average rental value of land in Lower Egypt is not far from $40 per acre, being much higher than the average rental value of land in the southwestern United States having similar capabilities of crop production.

While the cotton growers of Arizona and California have the advantage in respect to land rental or interest on land investment, those of Egypt are able to get their cotton picked at much less cost, owing to the cheapness and abundance of labor in that country. Aside from these two items, the cost of production is probably not very different in the two countries, since the low wage paid to farm laborers in Egypt is offset by the fact that the American farmer works with large fields and uses horse-drawn implements extensively. Much of the Egyptian crop, on the other hand, is grown by peasant farmers in small fields and with the use of very primitive implements.

The Egyptian industry suffers two serious disadvantages which do not exist in Arizona and California. One of these is the difficulty of maintaining pure seed, due to the widespread occurrence of Hindi, or "weed," cotton, which is discussed more in detail elsewhere in this bulletin. The other is the existence of certain insect pests, notably the pink bollworm, which has recently caused serious and extensive damage and is still spreading.

It is probable that the higher valuation of land in Egypt, together with the less efficient methods of tillage, nearly or quite offsets the higher cost of labor in the United States. The crop-producing capabilities of the land in the two regions are much the same. The commercial value of the Arizona crop compares favorably with the best of the Egyptian crop. Finally, the Egyptian cotton grown in

the United States is practically free from Hindi contamination, and the pink bollworm has not yet found its way into Arizona and California.

In the matter of transportation the Egyptian cotton crop enjoys certain natural advantages over the product of the new American industry. It also has the advantage of long-standing occupation of the market and of a well-organized, though rather expensive, system of commercial distribution.

The entire Egyptian crop is assembled in Alexandria, where it is sorted, classed, compressed, and forwarded. Practically none of the cotton is manufactured locally. This centralization of the marketing business permits, though it does not insure, efficiency and economy in the handling of the product. The freight rates from Alexandria to manufacturing centers, transportation being by water, are low in comparison with the rates from Arizona, which include a long rail shipment. Freight rates, particularly ocean freight rates, are subject to continual fluctuations, but it is probable that previous to the outbreak of the war the rates from Arizona and California[1] to manufacturing points in New England were about three times as high as those from Egypt to the same points. Under present conditions, however, the cost of shipment from Arizona is probably lower than from Egypt.

The large volume of the Egyptian crop and the centralized methods of handling also permit a standardization of types and a system of future selling against these types which are very important commercial advantages. To find favor in the market a consignment of cotton must not only show good grade and staple, but must represent a type which has had its merit established through actual use. A manufacturer having determined what types of cotton meet his particular requirements will endeavor to duplicate these types in his annual purchases. For this reason Egyptian brokers establish definite types and maintain them from year to year. This system of dealing on types is possible with the Egyptian crop in spite of the continued deterioration of the varieties, because each broker has a large volume of cotton offered to him at Alexandria from which to select his stocks.

The American growers will need to recognize this feature of the market for Egyptian cotton if they expect to secure full value for their product. While the American crop remains small, it is of the utmost importance that the quality be kept uniform from year to year.

[1] The Arizona cotton is usually shipped by rail to Galveston, Tex., and thence by water to New England. The freight rate on baled cotton from Salt River Valley points to New England is about $1.30 per 100 pounds, this rate including the charge for compressing in transit.

It is possible to maintain this uniformity of type in the American crop if the growers exercise proper care in the selection of seed for planting. Unless the seed is selected carefully and consistent effort is made by good tillage and careful picking and ginning to maintain uniformly high quality in the crop, it will be difficult, if not impossible, to maintain the new industry on a profitable basis.

EARLY ATTEMPTS TO ESTABLISH EGYPTIAN-COTTON GROWING IN THE UNITED STATES.

The Department of Agriculture on several occasions prior to 1900 imported seed of Egyptian cotton and distributed it in small lots to farmers throughout the cotton belt. This procedure did not result in establishing the industry in any locality, a fact that ceased to be surprising when the necessity for community action in the commercial production of a new type of cotton came to be appreciated. The tests of the imported seed in various localities gave diverse results as to yield and quality of the fiber produced, but serious difficulties were always encountered in communities where Upland cotton was already being grown. Some of these difficulties may be stated as follows:

(1) Pickers disliked the small bolls, which made it appear that picking would be much more difficult and expensive than in the case of the big-bolled Upland types which are generally popular in the South.

(2) Only saw gins were available for separating the fiber from the seed, and as a result the fiber was invariably injured in ginning.

(3) Marketing small lots of a new type of fiber, with which the local buyers were unfamiliar, was found to be extremely difficult.

(4) The Egyptian cotton was grown in the neighborhood of fields of Upland cotton, and consequently it was found impossible to keep the seed pure.

The seed of several of the best varieties grown in Egypt was imported in larger quantities by Mr. David Fairchild following his visit to that country in 1900 as an agricultural explorer for the Department of Agriculture.[1] Dr. H. J. Webber, then in charge of the plant-breeding work with cotton in the Department of Agriculture, undertook systematic tests of these varieties during the next two or three years at various localities in the cotton belt and in irrigated districts of the Southwest. In the main cotton belt fairly favorable results were obtained in certain localities, but owing to the difficulties mentioned the experiments did not result in the establishment of commercial production.

BEGINNING OF EXPERIMENTS IN THE SOUTHWEST.

The irrigated lands of southern Arizona and southeastern California, where the climatic conditions more nearly resemble those of Egypt than in the cotton belt, were found to offer the most promis-

[1] The first plantings of Egyptian cotton in Arizona appear to have been made with some of this seed, which was sent to the State (then the Territorial) experiment farm at Phoenix and to Dr. A. J. Chandler, at Mesa. This was a year or two before the beginning of experimental work with this crop in Arizona by the Department of Agriculture.

ing field for the introduction of this type of cotton. In the early stages of the work, however, serious difficulties were encountered in this region also. The most important of these were the following: (1) The lack of proper facilities for carrying on the plant-breeding work and the investigations of cultural methods; (2) lack of uniformity in the imported stocks of seed and slow progress in the development of a productive type having fiber of sufficiently good quality and uniformity to warrant its recommendation for commercial production; and (3) lack of information as to the proper methods of irrigation and culture under the climatic and soil conditions of the region.

It also become apparent that, even if these cultural difficulties could be overcome, certain economic problems would need to be solved before commercial production could be undertaken with any hope of success. These problems were as follows: (1) The scarcity and high price of labor in this thinly populated region, which threatened to make the picking so expensive that no profit could be anticipated; and (2) the difficulty of ginning and marketing the crop grown in a small way by farmers in localities remote from established cotton markets.

The first-mentioned difficulty was overcome when the Department of Agriculture established two well-equipped experiment farms where the plant-breeding work and the study of cultural methods could be carried on from year to year on the same soils and under the same management. One of these farms is the Cooperative Testing Garden at Sacaton, Ariz., conducted by the Bureau of Plant Industry in cooperation with the Office of Indian Affairs, Department of the Interior, and under the superintendence of Mr. S. H. Hastings (formerly of Mr. E. W. Hudson[1]). The other farm, at Bard, Cal., on the Yuma Reclamation Project, is conducted by the Bureau of Plant Industry in cooperation with the United States Reclamation Service and is under the superintendence of Mr. R. E. Blair (formerly of Mr. W. A. Peterson).

UNSATISFACTORY CHARACTER OF THE ORIGINAL STOCKS.

During the earlier years of the breeding work in Arizona the behavior of the plants was very unpromising. They made an extremely rank growth, but were relatively unfruitful and late in maturing. The bolls were small and often opened imperfectly. There was also

[1] Mr. Hudson, while superintendent of the Cooperative Testing Garden at Sacaton, took a very active part in the establishment of the industry in the Salt River Valley.

Mr. Argyle McLachlan, now president of the Imperial Valley Long-Staple Cotton Growers' Association, served for several years as field agent of the Department of Agriculture in the Southwest, and while his attention was devoted mainly to the Durango cotton industry in the Imperial Valley, he also aided effectively in the work with Egyptian cotton.

a pronounced lack of uniformity in the imported stocks and in the strains which were first selected from them.[1]

Mr. O. F. Cook, as a result of observations upon Egyptian varieties grown in Arizona from newly imported seed, reached the conclusion that the difficulty in obtaining uniformity was largely attributable to the presence among the Egyptian stocks of a very different and inferior type of cotton, the Hindi, the resulting cross-pollination having led to serious contamination of the Egyptian varieties. The matter seemed of sufficient importance to warrant an investigation in Egypt by Mr. Cook in 1910. The degree of Hindi contamination observed in that country was surprisingly great.[2]

Nearly every cotton field inspected was found to contain Hindi plants, and in some fields as many as 20 per cent of the plants were of the Hindi type. The percentage of pure Hindi plants does not represent the full extent of the damage, since this type crosses readily with the Egyptian cotton and the final result is a series of hybrids possessing in varying proportions the characters of each parent. Commencing with a mixed population of this sort, a uniform cotton can be developed only by the selection of an individual plant which possesses the characters desired and which breeds true, thus permitting the segregation of a pure stock.

Even if there were no Hindi cotton in Egypt, the conditions would be unfavorable for the maintenance of uniform varieties, since a number of distinct types of Egyptian cotton are grown, often in adjacent fields, and the pollen is readily carried from field to field by insects, leading to the production of intervarietal hybrids. Furthermore, until very recently no adequate precautions were taken to avoid the mixing of seeds at the gins.

DEVELOPMENT OF MORE UNIFORM VARIETIES.

Success in the effort to obtain a variety which could safely be recommended for commercial production was not attained until the variety called "Yuma" was segregated in 1908.[3] Although selected from a stock of Mit Afifi, the Yuma cotton is very distinct from that variety in the characters of the plants and of the fiber. The lint averages 1½ inches in length and has the pale pinkish buff color of the Jannovitch rather than the deeper buff color of the Mit Afifi. The lint percentage averages about 28.

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[1] Cook, O. F., McLachlan, Argyle, and Meade, R. M. A study of diversity in Egyptian cotton. U. S. Dept. Agr., Bur. Plant Indus. Bul. 156, 60 p., 6 pl. 1909.

[2] Cook, O. F. Hindi cotton in Egypt. U. S. Dept. Agr., Bur. Plant Indus. Bul. 210, 58 p., 6 pl. 1911.

[3] For a more complete description of this variety and a more detailed account of its history, see Kearney, T. H., Breeding new types of Egyptian cotton, U. S. Dept. Agr., Bur. Plant Indus. Bul. 200, 39 p., 4 pl., 1910. The Yuma and Pima varieties are also described by Mr. Kearney in an article entitled "Mutation in Egyptian cotton," in Jour. Agr. Research, v. 2, no. 4, p. 287–302, pl. 17–25, 1914.

Yield tests and spinning tests of the Yuma cotton carried on during several years demonstrated that a stable variety, uniform in its characters and producing fiber of good spinning quality, had at last been obtained. Seed was therefore placed in the hands of farmers in the Salt River and Imperial Valleys in 1912, with the results described on preceding pages.

From the Yuma variety there has originated another very distinct new type, which has received the name "Pima" and which surpasses the parent variety in earliness, size of the bolls, and length and quality of the fiber. The staple of the Pima variety ranges from $1\frac{5}{8}$ to $1\frac{3}{4}$ inches and the fiber is lighter colored than that of the Yuma variety. In cooperation with the Tempe Exchange, one of the cooperative growers' associations in the Salt River Valley, Pima seed was distributed from the Sacaton station in 1916 for planting 252 acres in an area isolated from all other cotton. These fields yielded at the rate of 1 bale per acre, 251 bales of 500 pounds having been produced. The Pima cotton having found immediate favor with spinners, the resulting seed was used in 1917 to plant 6,700 acres in the same district, which produced approximately 3,000 bales. Nearly 95 per cent of the cotton acreage in the Salt River Valley and the entire acreages of Egyptian cotton in the Yuma and Imperial Valleys are now (1918) of the Pima variety.

SOLVING THE PROBLEMS OF COMMERCIAL PRODUCTION.

As the work of establishing the new industry progressed it became apparent that the economic and agricultural problems could best be met by enlisting the cooperation of several men representing different lines of experimental work in the Department of Agriculture, each of whom was able to contribute special knowledge and experience. The cooperation was at first informal, but later, as the responsibilities increased, it was thought advisable to create a special committee to carry on this work. A "Committee on Southwestern Cotton Culture" was therefore appointed in 1910 by the Chief of the Bureau of Plant Industry.[1]

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[1] The personnel of the committee is now as follows:

K. F. Kellerman, Associate Chief of the Bureau of Plant Industry, is chairman of the committee.

C. J. Brand, Chief of the Bureau of Markets, has charge of the investigations in classing, marketing, and transportation.

O. F. Cook, Bionomist in Charge of Crop-Acclimatization and Cotton-Breeding Investigations, conducts investigations of the factors involved in the acclimatization of different types of cotton in the Southwest and of the relation of these factors to cultural methods. He has also taken the lead in developing the idea of community cotton growing as a means to the maintenance of uniform varieties.

T. H. Kearney, Physiologist in Charge of Alkali and Drought Resistant Plant Investigations, has charge of the breeding work with Egyptian cotton and of the investigations of the effect of alkali and other soil conditions upon the production of this crop.

C. S. Scofield, Agriculturist in Charge of Western Irrigation Agriculture, has charge of those phases of the work which involve cooperation with the United States Reclama-

It has been the policy of the committee since its organization to avoid a sharp segregation of the different fields of investigation. As a result, each member has felt free to offer suggestions and even to assume responsibility beyond the limits of his own field, while the more important issues which have successively arisen in connection with the establishment of the industry have been decided by the whole committee. It is believed that this committee cooperation has been of the greatest importance in the successful establishment of the industry, since it has resulted in focusing upon the problems the different points of view and different mental equipment and training of several independent investigators.

Cooperative action having thus been provided, the economic problems were attacked, as follows:

(1) The principle of community effort in cotton production was applied in the organization of associations of growers.

(2) A supply of labor sufficient for the earlier requirements of the industry was developed through the employment of Pima and Papago Indians as cotton pickers, the first experiments having been made at the Cooperative Testing Garden at Sacaton under Mr. Swingle's direction. Frank M. Thackery, formerly superintendent of the Pima Indian Reservation and now chief supervisor of farming in the Office of Indian Affairs, rendered effective cooperation in this work.

(3) Methods for classing the new product were worked out, and grade and staple types were established, first for the Yuma variety and later for the Pima variety, by J. G. Martin and George Butterworth, of the Bureau of Markets.

(4) The American and European markets for this type of cotton were investigated by representatives of the associated growers and of the Department of Agriculture, contacts with buyers and spinners were established, and outlets for the product on the basis of full market value were thus obtained.

(5) In cooperation with the associated growers, measures were taken to insure a supply of pure seed for planting each year.

COOPERATIVE ORGANIZATION OF THE GROWERS.

When the Yuma variety of Egyptian cotton developed by the Department of Agriculture had been shown to possess the qualities needed for successful commercial production, it was pointed out that the industry could be successfully established only by community effort and that the department stood ready to furnish a supply of seed for planting, provided the growers were able to form a cooperative association. Farmers in the Salt River Valley had watched with interest the experiments with Egyptian cotton at Sacaton and had conferred with the superintendent of the cooperative garden

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tion Service and has also conducted certain investigations of market conditions in the United States and in Europe.

W. T. Swingle, Physiologist in Charge of Crop Physiology and Breeding Investigations, has charge of those phases of the work which involve cooperation with the Office of Indian Affairs, including the arrangements for securing Indian labor.

Fred Taylor, Cotton Technologist of the Bureau of Markets, has the immediate supervision of the classing, marketing, and technological problems.

there regarding the outlook for commercial production and the methods of growing the crop. They were therefore ready to adopt the point of view of the department, and in the spring of 1912 about 30 farmers in the vicinity of Mesa organized an association. In the following year similar organizations were formed at Chandler and Tempe. Finally, in the spring of 1914, a central organization, known as the Salt River Valley Egyptian-Cotton Growers' Association was formed, with the Mesa, Chandler, and Tempe associations as its constituent members. The central organization was designed to look after the marketing of the crop and the maintenance of a supply of pure seed for the entire valley, while the local organizations continued to provide for the ginning of the cotton grown by their members and for financing the crop during the growing period.

The Mesa and Tempe associations now operate well-equipped ginning plants. The gin at Chandler has been leased and operated by a private company, and there is also a privately owned ginning plant at Phoenix. Additional gins have been built recently at these and other points in the Salt River Valley by a corporation which manufactures automobile tires and which has bought or leased extensive tracts of land for the growing of Egyptian cotton.

During the present year cooperative associations of Egyptian-cotton growers have been organized on the Yuma Reclamation Project, in the Imperial Valley, and in Fresno County, Cal.

It is not likely, nor is it necessary to the success of the industry, that all of the growers in a community will become active members of the cooperative growing and marketing associations, but it is of the utmost importance that all should adhere to the policy of the organizations as regards the production of a single variety and the use of carefully selected seed. The commercial reputation of the cotton produced in the region and hence the best interests of every individual cotton grower can be secured only by this means.

LABOR FOR PICKING.

From the beginning of the experiments with Egyptian-cotton production in the Southwest it has been realized that the high cost of picking would be one of the most difficult problems to overcome. Hand labor is neither abundant nor cheap in these southwestern irrigated districts, yet a cheap and abundant supply of hand labor has generally been regarded as essential to successful cotton production. Picking Egyptian cotton requires greater care and is more expensive than picking Upland cotton, owing to the smaller size of the Egyptian bolls and the necessity of avoiding an admixture of such trash as leaves and pieces of bolls. In picking long-staple cotton it is especially important to keep the seed cotton clean; otherwise the grade of

the lint is impaired and its selling value is much reduced. The Egyptian-cotton growers of the Salt River Valley have had to pay their pickers at least twice as much per pound of seed cotton as the growers of big-bolled Upland cottons in the Imperial Valley.

Notwithstanding these natural disadvantages, the problem of picking the crop of the Salt River Valley has been met successfully. The work has been paid at rates which allowed the pickers to make satisfactory wages. Although the industry has developed rapidly, no serious shortage of labor has yet been experienced. This has been due to the fact that the growers, through an active organization, have attacked the problem in a businesslike way. In the first place, many of the farmers had only small acreages and they and their families were able to do most of the picking. This distribution of the acreage among small farmers is very desirable and should be encouraged. There remained, however, a large acreage for which pickers had to be procured, in addition to the home supply of labor. For this purpose the floating population of the valley was drawn upon and Indians were brought in from near-by reservations.

There are two tribes of Indians in southern Arizona which include a large number of industrious and capable workers. The Pimas, who occupy a reservation adjoining the Salt River project, have taken up cotton growing to some extent on their own lands and have also been employed as cotton pickers by the white settlers. The Papagos occupy a large tract of land lying south of the Pima Reservation. There are several thousands of these Indians, and, as they lead a rather nomadic existence because of the uncertainty of the desert water supply, they find a season of cotton picking a congenial method of employment and have taken to it readily. In recent years several hundred of them have been engaged in the work throughout the picking season, with very satisfactory results to themselves and to the cotton growers. The rapid expansion of the industry in the last two years has necessitated tapping the sources of labor supply still farther afield. In 1917 numerous white cotton pickers from Texas and other States in the main cotton belt came to the Salt River Valley, and several hundred laborers were brought in from Mexico. Even more strenuous efforts were required to procure a sufficient number of pickers for the greatly increased acreage of 1918.

The present indications are that if the labor problem can be satisfactorily solved, the future of the industry is assured, at least so long as prices remain anywhere near their present level. While the cost of picking is high, the other costs of production are not excessive, and if the yields are good the value of the crop is sufficiently great to carry the picking cost and leave a satisfactory margin of profit to the grower.

COMMUNITY CREDIT FOR FINANCING THE CROP.

The production of cotton in a new region involves some arrangement for financing the crop until it can be sold. The expenses of production up to the time of picking are not much greater than with other farm crops, but ordinarily the pickers must be paid promptly, and the cost of picking, together with the cost of ginning, requires an outlay of funds greater than farmers can ordinarily meet without special credit arrangements. This is particularly true when cotton growing is being undertaken in a new region, because the marketing of the crop takes more time than when the industry is well established. Under such conditions the crop can rarely be sold as soon as it is ginned. It must be classed and assembled into uniform lots, and must move to market gradually if the best prices are to be obtained. Even in the case of the well-established cotton industry in Egypt the crop moves to the market very gradually, much of it not reaching the manufacturer until the following spring or summer. Meanwhile it must be financed.

In view of the uncertainties attending the marketing of long-staple cotton from a new locality, brokers are not likely to risk paying what they believe to be the full value of the crop if asked to take it unclassed in round lots, as it comes from the gin. For that matter, even when they have the advantage of a well-established market, farmers would probably benefit by holding their cotton in storage until it can be classed into even-running lots and sold with the least element of risk to the cotton merchant or the spinner.

The associated growers in the Salt River Valley have met this problem of financing the crop by a plan of community credit. Arrangements were made with local banks to secure the necessary funds. Each bale of cotton, as soon as it was ginned, was placed in storage and a receipt was issued against it, these receipts being used as collateral for loans through the association. In this way it was possible for the grower to procure money to defray his expenses for picking and ginning without losing possession of his cotton until it was finally sold to the manufacturer. In the absence of such a system of community credit, it probably would have been necessary for the grower to sell his cotton as soon as it was ginned for whatever price he could obtain.[1]

GINNING IN RELATION TO PRODUCTION.

The roller gin which is used for Egyptian cotton can not be operated as rapidly or as cheaply as the saw gin which is used for Upland

[1] In 1917 many growers in the Salt River Valley executed contracts with a corporation manufacturing automobile tires which undertook the financing of their crops in return for an option on the product.

cotton. The charge made for ginning Egyptian cotton in the Salt River Valley was until recently about $10 per bale, but was increased to $14 in 1917.

Instead of depending upon custom ginning two of the associations of cotton growers in the Salt River Valley operate their own plants. The experience of these farmers, which is in accord with that of farmers in the eastern cotton belt, indicates that the best results are obtained when the ginning is under the control of the producers. The market value of cotton may be very greatly reduced by careless ginning, and when the gin operator has no other interest than to secure the largest possible outturn the commercial value of the product is likely to be impaired.

Cotton ginning is a technical operation which requires experience and skill to secure the best results. The cooperative ownership and management of a gin by the growers does not in itself insure capable and efficient management, but it does afford the owners of the crop an opportunity to insist upon the work being properly done. This opportunity is seldom afforded when the cotton is handled by custom gins. In either case it is of the utmost importance to the growers that the crop be classed or graded by a capable and impartial expert as soon as it leaves the gin. Prompt grading serves to warn the farmer if either the picking or ginning is being poorly done and gives him this warning in time to enable him to have better work done.

The grower is interested in the way the ginning is done, not only because of its effect on the value of his lint, but also because of its relation to his supply of seed for planting. Where only uncontrolled custom ginning is available the grower has small chance of maintaining the purity of his seed.[1]

The opinion appears to be gaining ground among students of cotton production that the improvement of the industry depends fully as much upon good ginning as upon good cultivation or good picking. The surest way to obtain good ginning is by cooperative ownership and operation of the gins.

GRADING THE CROP.

It was pointed out on a preceding page that uniform grades of Egyptian cotton must be established and maintained from year to year if the crop is to find ready sale at its full value. In recognition of this fact steps were taken in 1913 to establish standards of the different types and grades produced in the crop of Yuma cotton of

[1] Experiments that demonstrate in a striking manner the readiness with which seeds of different varieties of cotton become mixed in commercial ginning establishments have been described recently by D. A. Saunders and P. V. Cardon. (Custom ginning as a factor in cotton-seed deterioration. U. S. Dept. Agr. Bul. 288, 8 p., 5 fig. 1915.)

that year. A cotton-grading expert was detailed from the Office of Markets and Rural Organization (now the Bureau of Markets) to cooperate with the growers' association for this purpose. The work was continued in 1914, the standards having been perfected and arrangements having been made for spinning tests in order that the cotton might be placed on a sound basis of market value. The scope and preliminary results of this standardization work were described in a report from the Office of Markets and Rural Organization.[1] In 1916 and 1917 similar investigations were conducted with the new Pima cotton, which, because of its longer and lighter colored fiber, required the establishment of new standards of grade and staple.

MARKETING THE CROP.

In the six years of commercial production of Egyptian cotton in Arizona the marketing of the crop has been attended by various vicissitudes, and the problem has not yet been completely solved. Until very recently the quantity produced was too small to permit active competitive buying, and at times the danger of monopoly by a single buying firm has been acute. Moreover, the small quantity of the product also made it difficult for buyers to interest spinners in these new cottons even when their spinning value had become well recognized. The growers have not thus far succeeded in establishing an effective selling organization on a cooperative basis, but if this can be done and the transportation difficulties which have recently been experienced can be overcome, the rapidly increasing size of the crop should greatly facilitate its disposal. Although differences of opinion exist among spinners as to the comparative merits of American Egyptian, Sakellaridis, and Sea Island cottons, there is substantial agreement that the Arizona and California product meets a real requirement in the long-staple cotton market.

It should be noted that ever since the establishment of the industry the crop has been sold each year in open competition with the vastly larger crop produced in Egypt. The effective organization of the Arizona growers and the intelligent application of the best principles in growing, handling, and marketing the crop and in maintaining the seed supply are largely responsible for this satisfactory result.

MAINTENANCE OF THE SEED SUPPLY.

It was pointed out in an earlier publication [2] what steps should be taken by the associated growers and what kind of assistance the

[1] Martin, J. G. The handling and marketing of the Arizona-Egyptian cotton of the Salt River Valley. U. S. Dept. Agr. Bul. 311, 16 p., 3 pl. 1915.

[2] Kearney, T. H. Seed selection of Egyptian cotton. U. S. Dept. Agr. Bul. 38, 8 p. 1913.

Department of Agriculture could furnish in guarding against the deterioration of the seed used for planting.

The growers in the Salt River Valley having signified their desire to cooperate with the department along these lines, experts were detailed during the summer of 1913 to rogue [1] a limited acreage of well-grown Yuma cotton in order to obtain seed for increase during 1914 and for general planting in 1915. In 1914 the department's experts, assisted by representatives of the Salt River Valley Egyptian-Cotton Growers' Association, rogued about 100 acres which had been planted with seed from the fields which were rogued in 1913. Every plant in this acreage was examined, and the unproductive and off-type plants, amounting to about 1 per cent of the total, were removed. The work was done early in July, soon after blossoming began, in order to take out the inferior plants before their pollen should contaminate those left in the field. Of the cotton grown from seed produced by fields which were rogued in 1914, about 100 acres were rogued during the summer of 1915, somewhat less than 1 per cent of the plants being removed.

In a 20-acre field of Yuma cotton which was rogued in 1916, 2 per cent of the plants were removed as being "off type."

A large part of the acreage planted to the Pima variety in 1916 and 50 acres of this variety in 1917 were rogued. The much greater uniformity of the new type was shown by the fact that whereas from 10 to 20 plants in every thousand of the Yuma variety had been removed, only from 2 to 4 plants per thousand of the Pima variety were taken out in roguing, although the latter variety was rogued much more rigorously than the Yuma.

The growers' association on its part has had the seed from the rogued fields ginned under such conditions as to avoid mixing with other seed, and also has had the seed sacked and tagged as it comes from the gins, in order to prevent mixture while it is held in storage. The rogued seed is placed by the association in the hands of careful farmers having good land sufficiently remote from other cotton to prevent crossing. The fields planted under these conditions are inspected during the summer, and the product of those which are properly grown and are otherwise satisfactory is ginned separately, in order to furnish seed for general planting the second year after the roguing is done. Thus, the seed used for general planting in 1918 was derived from the fields which were rogued in 1916, and that which will be used for general planting in 1919 has been derived from the fields rogued in 1917. It is believed that the seed from

[1] The importance of early roguing cotton fields intended to furnish seed for planting and the practicability of recognizing "off-type" plants in the early stages of their growth have been pointed out by Mr. O. F. Cook. (Cotton selection on the farm by the characters of the stalks, leaves, and bolls. U. S. Dept. Agr., Bur. Plant Indus. Cir. 66, 23 p. 1910.)

inspected fields can be sold for planting at a price very little above current oil-mill prices, thus removing the temptation to plant unselected seed because it is cheaper.

The fact that this plan for handling the supply of planting seed of the Yuma variety was in successful operation when the time came to introduce the Pima variety in the same locality made it possible to solve what would otherwise have been the very difficult problem of substituting one variety for another and yet keeping the new stock from being mixed with the old. Through the hearty and efficient cooperation of this growers' association it has been possible to supply, in 1918, pure seed of the Pima variety for planting approximately 70,000 acres, all of which was derived from the 250 acres planted near Tempe in 1916.

If the growers' associations continue to follow year after year the plan thus outlined, it is expected that deterioration, if it occurs, will be so gradual that there will be time for the substitution of another pure strain selected and multiplied at the plant-breeding station.

It is to be hoped that the associated growers in other communities which have undertaken the production of Egyptian cotton will deal with the problem of pure-seed maintenance in an equally effective manner.

AGRICULTURAL RELATIONSHIPS OF THE CROP.

The outstanding agricultural feature of cotton production in the Southwest is the value of the crop in the farm rotation. Alfalfa occupies a large part of the irrigated land in that region and is the basis of its agriculture; but the alfalfa fields after a few years become so badly infested with Bermuda grass and other weeds that their value is greatly impaired. It has been found that these old alfalfa fields, when thoroughly broken up and worked into good tilth, yield large crops of cotton. At the same time the intertillage of the cotton crop while the plants are young and the complete shading of the ground later in the summer effectually rid the land of weeds. One or two well-tilled crops of cotton following alfalfa will leave the land clean and in excellent condition for reseeding with alfalfa or for growing other crops. Because of its renovating value in the farm rotation, cotton is a valuable crop for irrigated land, quite aside from the cash returns it brings.

Less water is needed for the production of cotton than for the production of alfalfa, particularly early in the season. In fact, the total seasonal quantity of water needed for irrigating cotton is probably not much more than half that needed for the irrigation of alfalfa. The significance of this point lies in the fact that there is more irrigable land in Arizona and southern California than can be supplied with irrigation water. Hence, the growing of a crop which

permits economy of the water supply may permit the ultimate extension of the irrigated area.

Another advantage of cotton as a crop for the irrigated Southwest is the fact that the product is a staple and nonperishable commodity. Practically all of the other crops yielding high cash returns per acre are perishable and involve the hazard of deterioration or total loss if the market is temporarily oversupplied. Cotton, on the other hand, is not subject to rapid deterioration if properly protected and need not be sold while prices are unsatisfactory.

TILLAGE METHODS.

Methods of preparing the land for Egyptian cotton and of irrigating and cultivating the crop have been described in an earlier publication of the Department of Agriculture.[1] The essential features of these methods are: Early and thorough preparation of the land; careful leveling, so that the entire field can be irrigated uniformly; early planting, with precautions for getting the seed into moist soil, so that prompt germination and good stands can be secured;[2] late thinning, leaving the plants close together in the row; the sparing use of irrigation water until the plants blossom; thorough cultivation as long as the size of the plants permits; and frequent light irrigation after blossoming begins until the crop is fully matured.

Unless the land is properly leveled satisfactory control of irrigation is out of the question. In some parts of a field the cotton may fail to germinate or may remain stunted by drought, while elsewhere in the same field the crop may suffer for the opposite reason, overwatering of the plants, which results in too luxuriant growth, late opening of the bolls, greater damage from frost, and more difficult picking. Planting early is desirable not only to secure the advantage of the longer season but because the young plants are likely to show more normal habits of branching and fruiting if very hot weather is not encountered during the early stages of growth. Withholding irrigation from the young plants has the same object of avoiding too rapid growth, and the methods of thinning and spacing permit additional control of the behavior of the plants in the interest of early and abundant fruiting. Overluxuriance and late bearing are among the most frequent causes of low yields.

LATE THINNING AND CLOSE SPACING.

The Egyptian-cotton plant makes a very luxuriant growth on the irrigated lands of the Southwest. Because of this fact, it was

[1] Hudson, E. W. Growing Egyptian Cotton in the Salt River Valley, Arizona. U. S. Dept. Agr., Farmers' Bul. 577, 8 p. 1914.

[2] A method of accomplishing this has been described. See Hastings, S. H., A lister attachment for a cotton planter, U. S. Dept. Agr., C. P. & B. I. Cir. 2, 3 p., 1 fig., 1917.

thought necessary at first to plant the rows wide apart (as much as 5 feet) and to thin severely, leaving the plants finally 2½ to 3 feet apart in the row. Under these conditions each plant attained a large size and produced several long vegetative branches, or "limbs." It was also customary at first to do the thinning, or "chopping" as it is called, when the plants were very small and had only two or three leaves in addition to the seed leaves. While this system of planting and thinning sometimes gave good yields, it was found that the crop was so late in maturing as to be in danger of frost injury in the autumn, and also that the large size of the plants and their numerous vegetative branches made the picking very difficult and expensive.

Closer investigation of the branching habits of the plant developed the fact that these troublesome vegetative branches could be suppressed by delaying the thinning until the plants are 8 to 10 inches high and have 10 to 12 normal leaves, and by leaving the plants closer together in the row.[1]

The best spacing distance for the plants has been found to depend somewhat upon local and seasonal conditions. Mr. E. W. Hudson states that on rich alfalfa land and with irrigation properly managed 6 to 8 inches is about the right distance, while on new land the plants can safely be left 4 inches apart. This conclusion was reached, however, as a result of experiments with the Yuma variety. Plants of the Pima variety, being less inclined to become limby and having their lower fruiting branches better developed, should probably be spaced not closer than 10 to 12 inches on rich land. The thinning should be done in such a way as to result in suppressing practically all of the vegetative branches without stunting the growth of the central stem or shading too much the lower fruiting branches.

If growth becomes more luxuriant than was expected at the time of thinning, injurious crowding may still be avoided by taking out every second or third plant. Another expedient is the cutting out of every third row, which may be justified under extreme conditions of luxuriance, even after the plants have reached the flowering state, in order to keep the vegetation from becoming too dense to permit a normal development of the fruiting branches. That more space is required for plants that have not been held in check sufficiently in the early stages does not mean that advantages could be gained by wide spacing at first, which would result in still larger numbers of vegetative branches. The principle to be kept in mind is that the suppression of the vegetative branches makes it possible to

[1] These investigations were made by Mr. O. F. Cook and his assistants, and the details of the investigations, as well as the cultural recommendations resulting from them, have been published in several bulletins and circulars, for the titles of which see the last section of this paper on the literature of the industry.

secure a better development of the lower fruiting branches, those that contribute to the production of an early crop.

This new method of delayed thinning and of closer spacing of the plants has resulted in a much earlier development of the crop, as well as in making the picking much easier and cheaper. The time and manner of thinning are so important that they merit the closest personal attention of the grower, the more so as it is impossible to lay down general rules which will be equally well suited to each type of soil and to each season.

UNDESIRABILITY OF RATOONING EGYPTIAN COTTON.

The winters of southern Arizona and California are often mild enough to allow many of the old cotton stumps to remain alive in the ground, and it is possible to grow a second crop from them. This has suggested the ratooning of Egyptian cotton, a practice which has recently had some advocates in the Salt River Valley. Ratooning was formerly practiced in Egypt, but the system was discontinued in that country because of the poor quality of the fiber produced. The practice has also been thoroughly tested with Durango cotton in the Imperial Valley, where the results were unsatisfactory.

While ratooning saves the labor of spring planting and results in the earlier maturity of the crop, it has no other advantage. A perfect stand can rarely be had, and the seedling plants with which the gaps must be filled ripen later than the ratooned plants and produce fiber of different length and quality, making it impossible to obtain a uniform product from the field. It is questionable whether the very early ripening of the ratooned cotton is really a benefit, since it necessitates picking during the hottest season of the year. It would also be difficult to keep the land from becoming weedy if this method were followed. Finally, the practice of leaving the old stumps in the ground would favor the increase of such injurious insects and fungi as might gain a foothold in the locality. The advisability of replanting the fields each year with the best seed obtainable can not be too strongly urged.

ENEMIES OF THE CROP.

Fortunately, no very serious diseases or insect enemies of the crop have yet appeared in the Salt River Valley. A weevil, very closely related to the Mexican cotton boll weevil and capable of feeding upon and depositing its eggs in the bolls of cotton, is native to the mountains of southern Arizona, occurring on a wild plant somewhat nearly related to the cotton plant.[1] Neither this weevil nor the true Mexican boll weevil has as yet been observed in the cotton fields

[1] Cook, O. F. A wild host plant of the boll weevil in Arizona. *In* Science, n. s., v. 37, no. 946, pp. 259–261. 1913.

of the Salt River Valley. An aphis commonly attacks the young plants, and in 1914 it persisted in large numbers until late in the summer, but it has not been shown that this insect causes serious damage to the crop. Bollworms occur in small numbers, but have not thus far been a source of appreciable damage. The dreaded pink bollworm, which has recently played havoc with the cotton crop of Egypt and of Mexico, was discovered in 1917 at a few localities in Texas, but has not been observed in Arizona and California. It is to be hoped that measures taken by the Federal Horticultural Board will prevent its becoming established in the United States.

A sucking bug, of the group known as "cotton stainers," has recently caused some damage to cotton in Arizona.[1]

Certain fungous diseases, while rather common, do not appear to be severely injurious. The seedling cotton plants are subject to attack, especially when cold weather occurs after planting, by a species of Rhizoctonia, causing the disorder known as "sore shin." When this disease is very prevalent, some replanting is likely to be necessary, but the plants which survive soon cease to show any effects of the trouble. Small areas, particularly in old fields which have previously been in alfalfa, are subject to a root rot, which toward the end of the summer causes the cotton to die rapidly in well-defined spots. The percentage of the total acreage thus affected is small, and the disease does not appear to spread rapidly through the soil or to be a serious factor in production when a suitable rotation of crops is followed.

The cotton seedlings are also subject to a disorder known as leaf-cut,[2] which is apparently a physiological derangement not associated with a parasitic organism. The symptoms are mutilation of the leaves and sometimes the abortion of the growing point of the stem, resulting in the malformation of the plants most seriously affected. Since the plants are subject to this disorder only while very young, the system of late thinning eliminates its effects by permitting the "chopping out" of the malformed plants.

CONDITIONS OF SUCCESSFUL EGYPTIAN-COTTON PRODUCTION.

The experience gained in connection with the establishment of the community growing of Egyptian cotton in the Salt River Valley

Bailey, Vernon. The wild cotton plant (*Thurberia thespesioides*) in Arizona. *In* Bul. Torrey Bot. Club, v. 41, no. 5, pp. 301–306, 2 fig. 1914.

Coad, B. R. Relation of the Arizona wild cotton weevil to cotton planting in the arid West. U. S. Dept. Agr. Bul. 233, 12 p., 4 pl. 1915.

[1] Morrill, A. W. Eighth Ann. Rpt., Arizona Comm. Agriculture and Horticulture, 1916, pp. 46–48.

[2] Cook, O. F. Leaf-cut, or tomosis, a disorder of cotton seedlings. *In* U. S. Dept. Agr., Bur. Plant Indus. Cir. 120, pp. 29–34, 1 fig. 1913.

makes it possible to formulate the conditions which appear to be indispensable to the successful production of this crop in the United States. These are, briefly, (1) a growing season of about nine months, or several weeks longer than is required to mature a full crop of Upland cotton; (2) a reliable supply of water for irrigation; (3) labor sufficient to pick the acreage planted; (4) absence of other types of cotton in the locality, as otherwise pure seed and a uniform fiber can not be maintained; (5) an acreage sufficient to warrant the purchase of roller gins and other equipment and the employment of a competent classer in order to market the cotton in even-running lots of commercial size; and (6) the cooperative organization of the growers for the purpose of maintaining the seed supply, operating the gins, and marketing the crop.

Communities in which all of the above conditions can not be met are advised not to undertake the growing of Egyptian cotton. In any event, a new community which contemplates the growing of this crop should experiment at first on a small scale and under expert advice, in order to make sure before investing capital in the enterprise that the climatic and soil conditions are favorable to producing large yields and a good quality of fiber.

CONCLUSION.

The history of the establishment of Egyptian-cotton production in the Salt River Valley is believed to have more than a special or local interest, since it offers a good illustration of the numerous biological, agronomic, social, and economic difficulties encountered in developing a new agricultural industry and furnishes suggestions as to how these complex and diversified problems may be successfully solved. That cooperation is the keynote of success has become very clear in the progress of the present enterprise. In this instance cooperation has been maintained along the following lines:

(1) Cooperation among the investigators has brought to the solution of the special problems different equipments of technical training and knowledge and different points of view, while their collective judgment has been focused upon matters of general policy. The cordial and effective cooperation of the administrative officers of the Department of Agriculture has also been an important factor in this connection.

(2) Cooperation among the growers has made it possible to produce and market the crop economically and to maintain the uniformity and high quality of the variety grown.

(3) Cooperation between the growers and the investigators has made it possible to put into effect without delay the most improved methods of production and marketing. This cooperation has been maintained by personal contact, since, in addition to the field agents

of the department who have worked constantly in the community, members of the Committee on Southwestern Cotton Culture have made frequent visits to the Salt River Valley. The attitude of the officers and members of the growers' associations in their cooperation with the Department of Agriculture has been of the most cordial and helpful character and has been a very important factor in the establishment of the industry.

(4) Cooperation with the cotton manufacturers on the part of both investigators and growers has also contributed largely to the development of the industry. Manufacturers have assisted most willingly and effectively in making spinning tests of the product from time to time, and in furnishing both to the Department of Agriculture and to the growers' associations useful information concerning the cotton. This information has guided the growers to better methods of handling the product and has given the investigators helpful suggestions in connection with the breeding work. Some of the manufacturers interested in this type of cotton have visited the Salt River Valley in order to learn at first hand the condition and prospects of the industry, while representatives of the growers' associations and of the department have been welcome visitors at mills where the cotton is being utilized.

The policy of the Department of Agriculture in encouraging the production of long-staple cotton on the community basis is beginning to be appreciated by manufacturers and buyers, many of whom now realize that in order to obtain year after year ample quantities of cotton of unchanging character they must look to localities where the farmers are organized to grow only one kind of cotton, to prevent deterioration of the type by seed selection, and to class and market their crop as a unit.

LIST OF PUBLICATIONS BEARING ON EGYPTIAN-COTTON GROWING IN THE SOUTHWESTERN STATES.

The following is a list of publications dealing with the activities of the United States Department of Agriculture in connection with the establishment of Egyptian-cotton growing in the Southwest. Several of the publications listed do not deal directly with Egyptian cotton, but are included because they describe different phases of the investigations which have formed the basis for the establishment of this industry.

Egyptian cotton in the southwestern United States. By Thomas H. Kearney and William A. Peterson. Bureau of Plant Industry Bulletin 128. Issued June 13, 1908.

Suppressed and intensified characters in cotton hybrids. By O. F. Cook. Bureau of Plant Industry Bulletin 147. Issued April 7, 1909.

Experiments with Egyptian cotton in 1908. By Thomas H. Kearney and William A. Peterson. Bureau of Plant Industry Circular 29. Issued April 16, 1909.

A study of diversity in Egyptian cotton. By O. F. Cook, Argyle McLachlan, and R. M. Meade. Bureau of Plant Industry Bulletin 156. Issued July 24, 1909.

Local adjustment of cotton varieties. By O. F. Cook. Bureau of Plant Industry Bulletin 159. Issued September 28, 1909.

Origin of the Hindi cotton. By O. F. Cook. Bureau of Plant Industry Circular 42. Issued December 11, 1909.

Mutative reversions in cotton. By O. F. Cook. Bureau of Plant Industry Circular 53. Issued March 21, 1910.

Cotton selection on the farm by the characters of the stalks, leaves, and bolls. By O. F. Cook. Bureau of Plant Industry Circular 66. Issued August 13, 1910.

Breeding new types of Egyptian cotton. By Thomas H. Kearney. Bureau of Plant Industry Bulletin 200. Issued December 23, 1910.

Dimorphic branches in tropical crop plants: Cotton, coffee, cacao, the Central American rubber tree, and the banana. By O. F. Cook. Bureau of Plant Industry Bulletin 198. Issued January 14, 1911.

Hindi cotton in Egypt. By O. F. Cook. Bureau of Plant Industry Bulletin 210. Issued May 11, 1911.

Arrangement of parts in the cotton plant. By O. F. Cook and R. M. Meade. Bureau of Plant Industry Bulletin 222. Issued October 3, 1911.

Dimorphic leaves of cotton and allied plants in relation to heredity. By O. F. Cook. Bureau of Plant Industry Bulletin 221. Issued November 22, 1911.

Cotton improvement on a community basis. By O. F. Cook. Yearbook, U. S. Dept. of Agriculture, for 1911, pp. 397–410.

Suggestions on growing Egyptian cotton in the Southwest. By Carl S. Scofield. Bureau of Plant Industry Document 717. Issued January 9, 1912.

Results of cotton experiments in 1911. By O. F. Cook. Bureau of Plant Industry Circular 96. Issued July 17, 1912.

The branching habits of Egyptian cotton. By Argyle McLachlan. Bureau of Plant Industry Bulletin 249. Issued September 20, 1912.

Improved methods of handling and marketing cotton. By Charles J. Brand. Yearbook, U. S. Dept. of Agriculture, for 1912, pp. 443–462.

Morphology of cotton branches. By O. F. Cook. Bureau of Plant Industry Circular 109, pp. 11–16. Issued January 4, 1913.

Heredity and cotton breeding. By O. F. Cook. Bureau of Plant Industry Bulletin 256. Issued January 13, 1913.

Preparation of land for Egyptian cotton in the Salt River Valley, Arizona. By E. W. Hudson. Bureau of Plant Industry Circular 110, pp. 17–20. Issued January 18, 1913.

Fiber from different pickings of Egyptian cotton. By Thomas H. Kearney. Bureau of Plant Industry Circular 110, pp. 37–39. Issued January 18, 1913.

Egyptian cotton as affected by soil variations. By Thomas H. Kearney. Bureau of Plant Industry Circular 112, pp. 17–24. Issued February 8, 1913.

A wild host plant of the boll weevil in Arizona. By O. F. Cook. Science, n. s., v. 37, pp. 259–261. Issued February 14, 1913.

A new system of cotton culture. By O. F. Cook. Bureau of Plant Industry Circular 115, pp. 15–22. Issued March 1, 1913.

The fundamentals of crop improvement. By W. T. Swingle. Bureau of Plant Industry Circular 116, pp. 3–10. Issued March 8, 1913.

The abortion of fruiting branches in cotton. By O. F. Cook. Bureau of Plant Industry Circular 118, pp. 11–16. Issued March 22, 1913.

Leaf-cut, or tomosis, a disorder of cotton seedlings. By O. F. Cook, Bureau of Plant Industry Circular 120, pp. 29–34. Issued April 5, 1913.

Factors affecting the production of long-staple cotton. By O. F. Cook, Bureau of Plant Industry Circular 123, pp. 3–9. Issued April 26, 1913.

Egyptian cotton culture in the Southwest. By Carl S. Scofield. Bureau of Plant Industry Circular 123, pp. 21–28. Issued April 26, 1913.

Agriculture on the Yuma Reclamation Project. By Carl S. Scofield. Bureau of Plant Industry Circular 124, pp. 3–8. Issued May 3, 1913.

Cotton farming in the Southwest. By O. F. Cook. Bureau of Plant Industry Circular 132, pp. 9–18. Issued July 19, 1913.

The occurrence of a cotton boll weevil in Arizona. By W. Dwight Pierce. Journal Agricultural Research, v. 1, no. 2, pp. 89–96. Issued November 10, 1913.

Seed selection of Egyptian cotton. By Thomas H. Kearney. U. S. Dept. of Agriculture Bulletin 38. Issued November 19, 1913.

Cotton as a crop for the Yuma Reclamation Project. By the Committee on Southwestern Cotton Culture. Bureau of Plant Industry Document 1009. Issued December 1, 1913.

Notes on the entomology of the Arizona wild cotton. By W. D. Pierce and A. W. Morrill. Proceedings Entomological Society of Washington, pp. 14–36, v. 16, no. 1. Issued March 1, 1914.

The relation of cotton buying to cotton growing. By O. F. Cook. U. S. Dept. of Agriculture Bulletin 60. Issued February 16, 1914.

Growing Egyptian cotton in the Salt River Valley, Arizona. By E. W. Hudson. U. S. Dept. of Agriculture, Farmers' Bulletin 577. Issued March 14, 1914.

Mutation in Egyptian cotton. By Thomas H. Kearney. U. S. Dept. of Agriculture, Journal of Agricultural Research, v. 2, no. 4, pp. 287–302. Issued July 15, 1914.

The wild cotton plant (*Thurberia thespesioides*) in Arizona. By Vernon Bailey. Bulletin Torrey Botanical Club, v. 41, pp. 301–306. Issued May 29, 1914.

Single-stalk cotton culture. By O. F. Cook. Bureau of Plant Industry Document 1130. Issued December 14, 1914.

Relation of the Arizona wild cotton weevil to cotton planting in the arid West. By B. R. Coad. U. S. Dept. of Agriculture Bulletin 233. Issued May 27, 1915.

Single-stalk cotton culture at San Antonio. By Rowland M. Meade. U. S. Dept. of Agriculture Bulletin 279. Issued August 24, 1915.

Custom ginning as a factor in cotton-seed deterioration. By D. A. Saunders and P. V. Cardon. U. S. Dept. of Agriculture Bulletin 288. Issued September 7, 1915.

The handling and marketing of the Arizona-Egyptian cotton of the Salt River Valley. By J. G. Martin. U. S. Dept. of Agriculture Bulletin 311. Issued November 26, 1915.

Community production of Durango cotton in the Imperial Valley. By Argyle McLachlan. U. S. Dept. of Agriculture Bulletin 324. Issued December 22, 1915.

Community production of Egyptian cotton in the United States. By C. S. Scofield, T. H. Kearney, C. J. Brand, O. F. Cook, and W. T. Swingle. U. S. Dept. of Agriculture Bulletin 332. Issued January 13, 1916.

Comparative spinning tests of the different grades of Arizona-Egyptian with the Sea Island and Sakellaridis Egyptian cottons. By Fred Taylor and William S. Dean. U. S. Dept. of Agriculture Bulletin 359. Issued March 30, 1916.

Tests of Pima Egyptian cotton in the Salt River Valley, Arizona. By Thomas H. Kearney. U. S. Dept. of Agriculture, A. & D. R. P. I. Circular 1. Issued December 6, 1916.

Cotton pests. By A. W. Morrill. Eighth Annual Report, Arizona Comm. Agriculture and Horticulture, pp. 45–49. Issued December 30, 1916.

A lister attachment for a cotton planter. By Stephen H. Hastings. U. S. Dept. of Agriculture, C. P. & B. I. Circular 2. Issued March 27, 1917.

A plant industry based upon mutation. By Thomas H. Kearney. In Journal of Heredity, v. 9, pp. 51–61 (1918).

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